



**STRATEGY  
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**RATIONALIZATION AND MODERNIZATION OF DEFENSE  
CONTRACTORS AFTER MERGERS AND ACQUISITIONS**

**BY**

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CONTRACTORS AFTER MERGERS AND ACQUISITIONS

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## ABSTRACT

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The intent of this SRP is to identify means to make contractor more efficient, to reduce cost of the government weapon systems and meet the services Objective Force transformation ends. The assumption is after acquiring or merging with other competitors, contractors did not modernize nor rationalize their operations to the maximum extent possible. The cost of that inefficiency is being paid for by the government; however, with some innovation changes to our funding contract language and regulations, the government (DoD) can achieve significant savings. At the same time, contractor operations will be more modern, more effective and efficient, and allow for future growth.



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## **RATIONALIZATION AND MODERNIZATION OF DEFENSE CONTRACTORS AFTER MERGERS AND ACQUISITIONS**

Over the past two decades, the American defense industrial base has undergone significant change. During this period, the industry base has experienced numerous mergers and acquisitions for a variety of reasons. This paper examines those mergers and acquisitions identifying contractor shortfalls (rationalization and modernization) that have resulted in an increase in the overall cost of the Department of Defense (DoD) contractor supported programs. During this same time, DoD budget has maintained a fairly level funding line causing the quantity reduction or outright cancellation of some defense support programs. Additionally, the paper describes existing and potential programs/actions capable of assisting the Department of Defense and its contractors in the rationalization and modernizations of their facilities and operations. The potential outcome is the generation of a cost savings to the supported programs.

### **DEPARTMENT OF DEFENSE (DOD) INDUSTRY**

In order to understand where we are today, we must go back to where we started. Historically, the government produced military related items during the inter-war years at the various arsenals and depots owned and operated by the government. Then a transition started. The government provided the facilities and equipment while the government contractor provided the labor (service industry). In the early 1980s, defense contractors increased their capital investments to buildup their infrastructure.<sup>1</sup> In the 1990s, a reducing defense budget drove these same companies to merge and acquire with the intent to reduce capacity. These mergers and acquisitions included significant market premiums, which were paid, driving up the asset base. In 1993, DoD, led by the Under Secretary of Defense for Technology and Acquisition (Mr. John Deutch), tried to execute a post-merger consolidation policy. However, the Congress passed regulations restricting/limiting payments on restructuring cost on plant and company rationalization.<sup>2</sup>

### **INDUSTRY IN TRANSITIONS**

After almost twenty years of mergers and acquisitions, it has been said that defense companies merge to create large vertically integrated companies which could have an adverse affect on smaller companies (financially and technically).<sup>3</sup> My experience is some companies have gone back to only "core" competencies thus getting away from vertical integration. Regardless, the investment community, in viewing the defense industry, sees a failure to

successfully manage the rationalization process. Thus they have serious concerns about investing into this market place.<sup>4</sup> Why do the investment communities and others say this? Probably due in part to the industry contractors trend to reduce overhead and operating costs by significantly reducing the workforce but not the facilities.

Thus, many contractors have not completed the rationalization process and their facilities are operating at 50 percent of capacity.<sup>5</sup> In particular, the U.S. aircraft industry (aircraft, rotorcraft, and jet engines) are competing against European firms from a weakened position. They must reduce overhead, streamline production process, and enter into strategic partnership in order to maintain market share.<sup>6</sup>

Besides accomplishing the above, the defense industrial base must be closely integrated with the commercial marketplace and exploit those technologies that come from it.<sup>7</sup> They need to accomplish this as DoD seeks the commercial marketplace for similar resource items (human capital, technology).<sup>8</sup> In addition, Defense Science Board Task Force expects DoD industry contractors will expand or become more of a technology integrator. Also, they should anticipate smaller production runs, fewer new starts, increasing international business base competition and a rapidly changing technological environment.<sup>9</sup>

## **DEPARTMENT OF DEFENSE (DOD) AS A CUSTOMER AND TRENDS**

When industry deals with DoD there are many reservations. First, DoD must come to closure on a realistic requirements to match against industrial capabilities. DoD cannot continue to think that everything a warfighter asks for can be delivered. Adjustments, even at the level of tactics, may be required where industry proves unable to meet stated requirements.<sup>10</sup>

Second, nuclear war is unlikely, thus a dependence on conventional non-nuclear war is more likely. In view of the declining industrial base, DoD must determine how to keep critical industry lines alive during periods of reduced budgets and a decline in the number of weapons systems.<sup>11</sup>

Third, contractors claim only meager returns and uncertainty about future revenue, profit, and cash flow. Most defense contractors want predictability instead they get a lot of negative surprises and serious doubts about their management.<sup>12</sup> The investment community probably best describes the defense customer as unreliable and capricious.<sup>13</sup> Finally, today, DoD is relying on more information assets and not primary traditional platforms.<sup>14</sup> In the future, the importance of commercial technology, products, and production capacity will increase.<sup>15</sup> One only has to look at the Acquisition Reforms being pursued by DoD and Federal Acquisition Regulation (FAR) Part 12 changes to see the change.

## DEPARTMENT OF DEFENSE (DOD) POLICY ON CONSOLIDATION/MERGERS

DoD changed its profit policy, retroactively to 18 October 1986. The policy placed an emphasis on facilities capital investment and contractor risk. Specifically, it increased "emphasis on risk and facilities capital employed" while decreasing emphasis on cost.<sup>16</sup> In 1987, the Logistic Management Institute (LMI) study stated that recent studies had shown that contractors had made higher profits on government contract work than on their commercial work. At the same time, productivity improvements were less on the government contracts.<sup>17</sup> During the time period 1993-1998, DoD encouraged the consolidation and mergers of industry. This was done to reduce the amount of assets earmarked for defense. In the long run, it was determined that industry needed to make this happen to maintain a healthy defense industrial base (government and commercial sectors).<sup>18</sup> This policy expected industry to make rational business decisions thus reducing assets dedicated to defense. However, the DoD leadership knew they could not direct industry to do so. Congress did not like the policy because downsizing meant a loss of jobs in many Congressional districts.<sup>19</sup> Mr. John Deutch, former Undersecretary of Defense for Acquisition and Technology, stated that the Congressional actions slowed down the asset downsizing process; however, employment continued to decrease due to defense spending reductions.<sup>20</sup> During the 1990s, industry saw a 40 percent reduction in DoD expenditures (procurement, construction and Research and Development (R&D)) combined. This was one of the main reasons for industry to consolidate. However, the government focus on industry consolidation was to reduce plant, property, and equipment (physical assets).<sup>21</sup> The two parties had different motives or approaches to consolidation. From 1993 to 1999, the top five defense contractors reduced tangible assets by seven percent. Total assets (tangible and intangible) had increased by 32 percent and firms had become more efficient; however, industry had no incentive to reduce tangible assets further because the sharing cost saving incentives had disappeared.<sup>22</sup> A U.S. General Accounting Office (GAO) study on government acquisition reform, identified that all consolidation studies savings (estimated \$5.6 B) were all based upon management judgment alone. The report did not identify any achieved real savings. The report also showed that contractors seemed to be optimistic in their projection while government estimates were conservative.<sup>23</sup> So what have all these changes caused? The defense industry today is in a different position than was envisioned in 1993. Significant assets were not reduced, defense spending/investments are flat, and profit margins are reduced. Credit ratings have decreased, so the cost of capital (used for mergers and consolidations) has increased.<sup>24</sup> After numerous consolidations, the following

judgment appears to be true: "Industry has excess capacity and some companies have failed to take aggressive rationalization action"; high costs remain along with a constrained budget, thus limiting our ability to meet modernization goals; and DoD policies do not incentivize companies to reduce costs and rationalize (efficiency and downsizing) facilities.<sup>25</sup>

## **WHAT IS THE COST DRIVER ASSOCIATED WITH THE PRODUCTION BASE?**

DoD and Department of Labor (DOL) reviewed certain sectors of the DoD industry, which a determination on cost was needed. A prime example was the budgets for aircraft procurement, which doubled from 1973 to 1993, in a period when 65 percent fewer aircraft were produced.<sup>26</sup> Significant cost growth had occurred. Defense related employment decreased by 39 percent (1987 to 1997), a rate of almost 5 percent per year but the cost per product increased.<sup>27</sup> During this time, total unemployment did not increase.

There are two basic types of contracts awarded: fixed price and cost reimbursement. Each of these contract types might have other incentives attached. These contract types are described below. "Fixed price contracts are appropriate when stable and reasonably definite specifications are available; production experience is present; and cost, schedule, and performance risk are low. Cost reimbursement contracts are considered appropriate when level of effort required is uncertain and cost cannot be accurately estimated. Also, cost reimbursement contracts are recommended when it is expected that there will be a large number of major technical changes in a project or when unpredictable actions beyond the control of the contractor may influence contract performance."<sup>28</sup> Changes in threat, requirements, program funding, program schedule and technical challenges are a few examples of uncertainties that may be encountered.

The contractor has the ability to control cost in his areas of responsibility. One of these areas is overhead cost. Overhead costs are those costs that support a total company's business and not a specific contract. These costs include facilities and equipment, salaries for managers, general and administrative support operations, computer operators and security.<sup>29</sup> "DoD estimates that overhead cost on average represent about one-third of a contractor's price."<sup>30</sup> Depending on contract type, the allocation is different.

The GAO study of six defense contractors found they had reduced overhead by reducing indirect labor employees, cutting benefits (healthcare), reducing independent research and development expenditures and consolidating facilities, however, the report showed that sales in four of the six companies were reducing faster than overhead (OH) cost, thus an increase in OH rates is expected. The study indicated the projection was \$1.50 OH cost for every dollar of

direct labor in 1993. This is expected to increase to \$1.76 to \$1 direct labor in 2001.<sup>31</sup> This will decrease a program's ability to procure more product for its customer.

The GAO study found that defense contractors targeted facilities, indirect labor and fringe benefits as sources to reduce OH cost. The largest driver appeared to be indirect labor which all contractors targeted. However, data showed that the business unit, which did not reduce facilities, had the highest increase in composite OH rates (17%) at the end. OH rates are used to allocate a contractor's overhead to its contracts, and increases in the rate could cause individual contract cost (cost type contract) to rise. This would cause individual programs cost to rise, reducing the purchase quantity or contract threshold.<sup>32</sup> This result can be attributed, in part, to maintaining the 1980s capacity buildup, that increased the fixed cost that must be paid during times of lower production. Today, conservative estimates state that the aerospace industry operates at less than 50 percent capacity, ship building 20 percent, and machining 10 percent. This drives up the overhead cost on a per unit base, reducing the quantity procured.<sup>33</sup> In summary, today's weapons cost more per unit than in the past, so that fewer can be procured as the defense budget declines or remains flat. Changes in complexity and sophistication of today's weapons, and costs associated with related weapons manufacturing (i.e., facilities, direct labor, indirect labor, and OH) processes have contributed to this trend.<sup>34</sup>

## **CONSOLIDATION OF THE DEFENSE INDUSTRY**

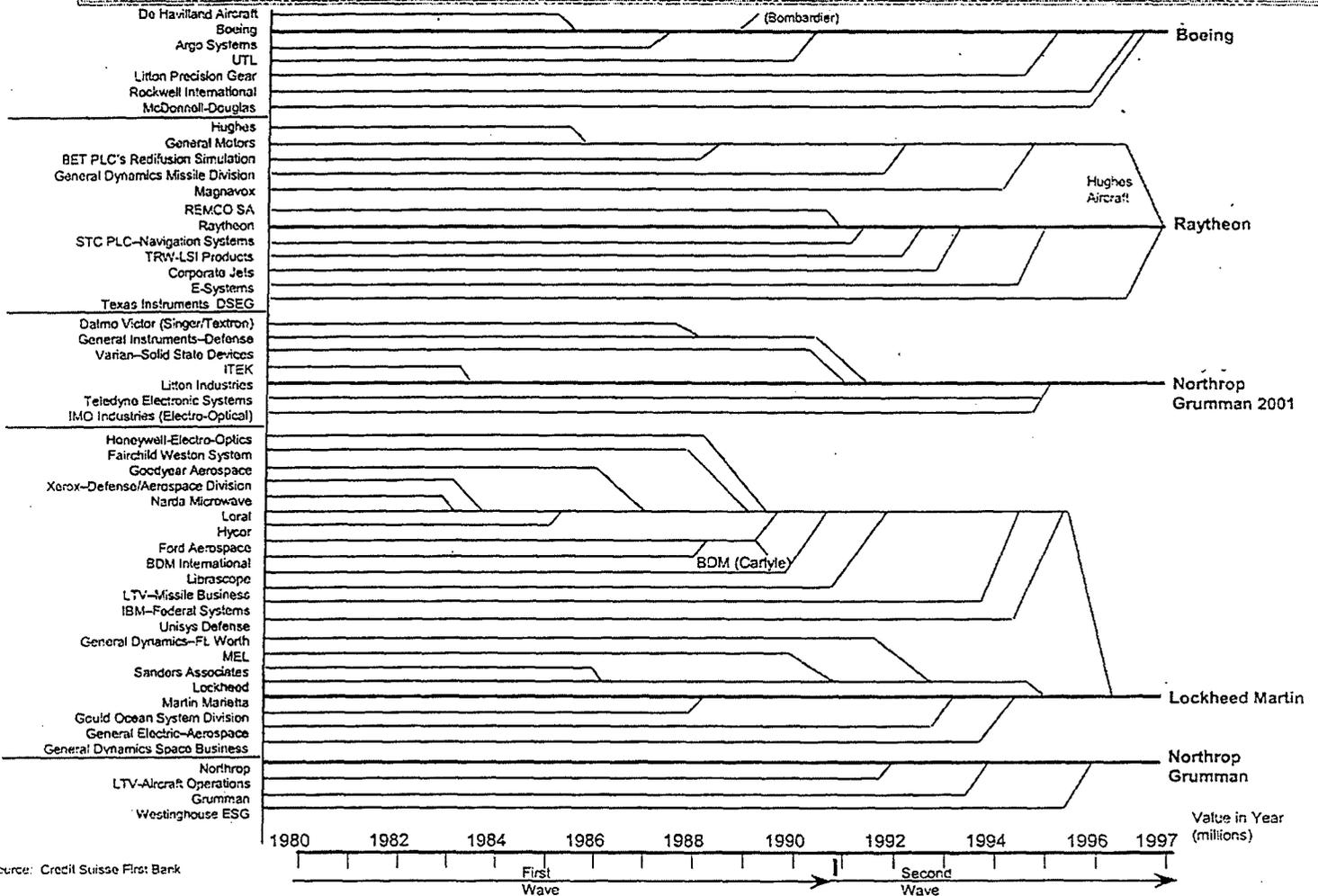
During the inter-war years, the government used to sustain military technologies through their arsenals; however, since the government has come to rely on private contractors for sustainment.<sup>35</sup> Industry grew to accommodate that need. Since 1985, a decline in the spending has caused consolidation with the defense industry. During recent years since, over 50 mergers and acquisitions have taken place and now competition has become a concern.<sup>36</sup>

A graphic representation of these consolidations can be found in Table 1. Table 1, an Office of the Deputy Undersecretary of Defense (Industrial Policy) briefing slide, depicts the significant changes over the last 20 years and a reduction of the defense firms to four major contractors not three as stated in slide title.<sup>37</sup>

While significant changes in the number of DoD contractors were unexpected, DoD expected to see significant cost savings from these consolidations. DoD encouraged the consolidations of contractors facilities, elimination of excess capacity for competitive reasons, and financial viability.<sup>38</sup> DoD did not get what it bargained for.

Since 1990, the number of companies in almost all defense sectors has significantly decreased. Table 2 identifies the concentration within the sector.<sup>39</sup> In addition, the Tracked Combat Vehicle sector has decreased from 3 to 2 competitors during this period (1990-98).<sup>40</sup>

**Consolidation of Some Defense Firms, e.g., 51 Business Units to 3 firms**



Source: Credit Suisse First Bank

256

U.S. Industry Platform Competitors: 1990 vs. 2000:  
Platform Markets have become significantly concentrated

Industrial Sector	Companies (1990)*	Companies (2000)*
Fixed-Wing Aircraft	8	3
Helicopters	4	3
Satellite Integrators	8	6
Space Launch Vehicles	6	3
Strategic Missiles	3	2
Submarines	2	2
Large Surface Ships	8	2**
Tactical Missiles	13	3
Tactical Wheeled Vehicles	6	3
Tracked Combat Vehicles	3	2

\* Companies producing products in stated year. Not all companies produce all classes of products within a given product area.

\*\* Reflects Northrop Grumman acquisition of NNS in 2001

Department of Defense, 28 January 2002

TABLE 2

Defense contractors consolidated in order to survive. In order to survive, they attempted to gain market shares and be competitive through their mergers and acquisitions. They reorganized, restructured, and reconfigured job duties, laid off people, and disposed of jobs. They supposedly reduced supplier and subcontractor base as well. They entered into team concepts and joint ventures in which they subcontracted with one another. They tried to expand defense marketing to international customers to increase sales. And finally, they sold and are selling off non-core, non-defense business units, getting out of non-niche markets, and exiting some defense industrial sectors altogether.<sup>41</sup>

As demand declined, defense industry consolidated without appearing to reduce competition, and achieving initial sizable cost savings.<sup>42</sup> Now, "DoD has concluded that consolidation carries the risk that DoD will no longer benefit from the competition that encourages defense contractors to reduce cost, improve quality, and stimulate innovation."<sup>43</sup> Merger and acquisition critics claim the consolidation has increased the cost of products and not produced enough consolidation savings. Additional efficiencies could have been achieved if contractors had streamlined and rationalized facilities.<sup>44</sup>

## **DEFENSE CONTRACTOR OVERCAPACITY**

In light of the numerous mergers and consolidations, U.S. Defense firms still have internal restructuring opportunities to reduce underutilized capacity, reducing net costs to DoD and increasing the ability to execute more efficient line processes.<sup>45</sup> It is a challenge for DoD to get industry to "right-size" while maintaining competition, innovation, interoperability and financial stability.<sup>46</sup>

This challenge of overcapacity must be overcome. The challenge is to reduce the leftover Cold War buildup overcapacity without undermining our ability to design and produce advance future weapons.<sup>47</sup>

Sustaining underutilized capacity costs hundred of millions of dollars annually in overhead, thus affecting contract cost, as explained previously.<sup>48</sup> Thus, DoD continues to encourage contractors to rationalize facilities, assets, and streamline operation through internal restructuring steps. If a contractor completes the rationalization, lower overhead costs are expected.<sup>49</sup> This internal restructuring would allow the adoption of manufacturing line flexibility and commercial processes providing efficiencies that would further reduce the cost to the government and increasing the opportunity for military and commercial integration.<sup>50</sup>

Even though overcapacity appears to be a major problem, there are times when a contractor is called upon to surge. Since 1995, there have been more than 100 cases where

Defense Priorities and Allocation System (DPAS), identified under the U.S. Defense Production Act, have been implemented. The enactment of DPAS directs the reallocation of material, services and facilities to meet an immediate national requirement. The majority of these (70%) have been implemented to support small scale contingencies in which the United States was engaged.<sup>51</sup> Some overcapacity is required at times.

At this time, the following are examples of the amount of overcapacity existing in the DoD industry. In the Fixed Wing Aircraft industry sector, consolidations and mergers have reduced the number of companies from 8 to 3 during the 1990-2000 timeframe.<sup>52</sup> Additionally, fixed wing aircraft production went from 450 to 100 units.<sup>53</sup> Department of Defense, with support of the Institute for Defense Analysis, conducted a study that found industry still employs only one less final assembly plant for fixed wing aircraft than in 1985.<sup>54</sup>

In the Rotary Wing (helicopter) industry sector, two major companies merged in the late 1990s; however, since that time the contractor has not reduced the excess capacity at its two locations. It is the expectation of Industrial Analysis Support Office (IASO) Defense Contract Management Agency (DCMA) that the contractor will, in the long term, consolidate to the most cost effective location.<sup>55</sup>

The IASO report stated excess capacity existed at 3 rotorcraft (helicopter) manufacturing sites and one company was actually expanding capacity (building a new facility).<sup>56</sup> The report stated that Contractor "A" facilities capacity were operating at 39 percent and expected to stay there. This percentage has decreased since 1994 when they operated at 60 percent capacity.<sup>57</sup> Contractor "B's" workload and capacity utilization remained in the 55-58 percent range over the period 1993 to 2001, while employment over the same time period had decreased over 20 percent.<sup>58</sup> An additional rotary wing site, acquired by Contractor "B", recently has increased utilization from 24 percent in 1993 to 40 percent where it is expected to remain. Contractor "B" is undergoing restructure efforts to shift capabilities from this site to other Contractor "B" sites while providing the support to the single type of airframe produced at the site.<sup>59</sup> Contractor B, to meet its performance goals, continues to work on inventory turnover, supplier base management, and facility consolidation.<sup>60</sup> The final contractor, Contractor "C's", capacity utilization is expected to decrease to 40 percent in 2001 from a high of 50 percent in 1999. The contractor operated at 47 percent in 1993. This contractor has significantly reduced (36 percent reduction since 1993) the number of personnel.<sup>61</sup> The following tables (Table 3 and 4), show that the rotary-wing aircraft industry has reduced in employment by about 10 percent from 1997 to 2000. Also, there has been a slight reduction in contractor facility space (5 percent). Even though these tables show an increase in sales (20 percent in dollars), one cannot assume a

significant increase in aircraft ordered. As noted previously, a portion of the sales increase is caused by an overhead cost rate change.<sup>62</sup> The Rotary-wing contractor industry consolidation could be expected if any ongoing ACAT I rotary wing programs are restructured without offsetting work or foreign military sales.<sup>63</sup>

In summary, "American industry has hardly done much to restructure or improve its efficiency since the end of the Cold War."<sup>64</sup> The defense industry has a significant over capacity and is not utilizing it efficiently or effectively.

### US ROTARY-WING AIRCRAFT INDUSTRIAL TRENDS

This table shows the Total Employment, Square Footage, Sales and DoD Workload Distribution for Rotary-Wing Aircraft at the Prime Military Contractor Site

	1997	1998	1999	2000
Employment	26,365	26,249	25,513	23,807
Square Footage (Thousands)	13,531	13,360	13,763	12,875
Sales (\$M)	4,047	4,022	4,531	4,845
DoD/FMS/Direct FS Workload Distribution (% Sales)	67%	64%	60%	65%

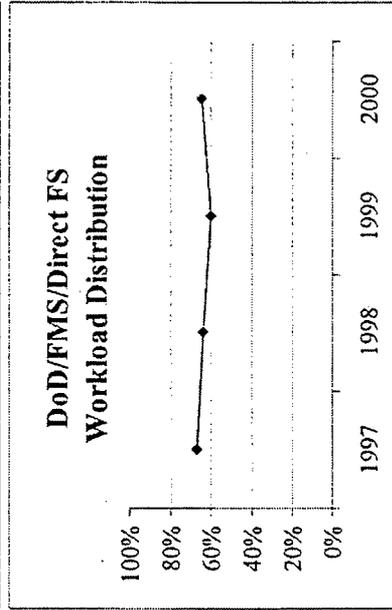
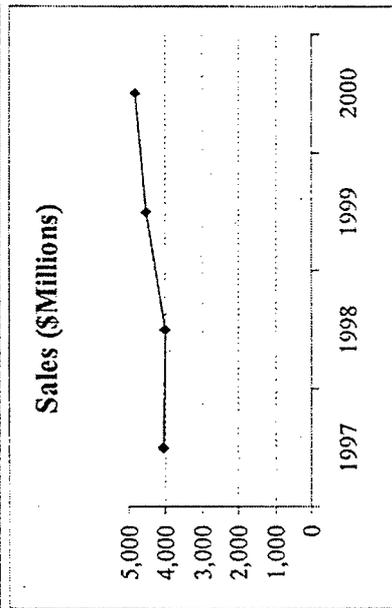
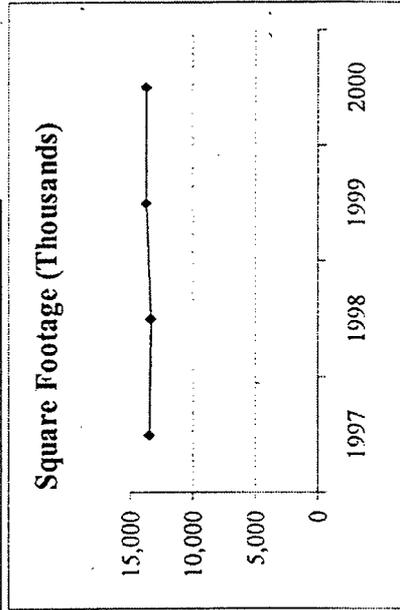
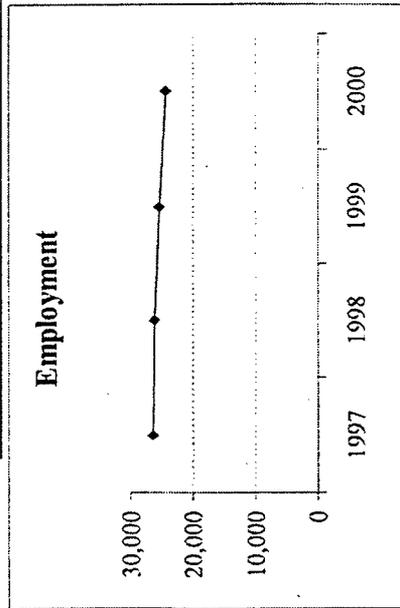
TABLE 3  
(Source DCMA)

TABLE 4

DRAFT

# US Rotary-Wing Aircraft Industrial Trends

These charts are the graphic representation from the table on the previous page.



DRAFT

Source: DCMA

## INDUSTRY RESTRUCTURING AND COST SAVINGS

The government anticipates a cost savings or benefit after industry announces a restructuring. Booz-Allen and Hamilton responded that in the three year period prior to 2000 the industry cost base was reduced by \$9 billion dollars. According to BAH, these savings were from “aggressive rationalization of redundant capabilities and excess capacity in the wake of the merger wave.”<sup>65</sup> So one must ask where are these savings? Companies claim that the cost savings generated are usually offset against a rise in cost when a program reduces its quantity. The customer, DoD does not perceive or realize that as a cost savings.<sup>66</sup>

Additionally, DoD pays for some up-front costs during a company’s consolidation or rationalization through the “cost-plus” contracts.<sup>67</sup> It is expected that these will eventually generate cost savings for DoD.

In assisting contractors and DoD, Congress passed Section 818, Public Law 103-337, requiring DoD to provide Congress with cost savings data from mergers and acquisitions when DoD reimbursed contractors for restructuring costs. It was found that contractor estimates were higher than what DoD could verify. Follow-up GAO reports state that contractors had reduced overhead rates initially by consolidation and other means, but were expecting in the future, an increase in the overhead rate.<sup>68</sup>

The government expected to see a cost savings of between \$1.50 and \$7 for every dollar spent in restructuring. When examining the Martin-Marietta and General Electric (GE) Aerospace merger, eight certified projects were expecting returns of \$2.73 per dollar spent for five projects and \$76.84 per dollar spent for the remaining three projects. After certification, the projection is \$2.41 (88 percent of estimate) and \$8.02 (about 10 percent of estimate). The total expectation was a \$5.24 reduction for every dollar spent but certification showed only \$2.57, 49 percent below projection.<sup>69</sup> The restructuring cost in five of the certified areas reduced the projected overhead (OH) cost \$2.01 for every dollar spent. Using the lower OH rates, procurement activities will be able to lower DoD contract prices.<sup>70</sup> The GAO study stated that the verifiable cost savings for this merger and restructuring were less than 50 percent of the initial estimate in eight projects reviewed in the Martin-Marietta Corporation acquisition of General Electric Company.<sup>71</sup>

Another merger with restructuring costs that GAO reviewed was the consolidation of FMC and Harsco-BMY. The initial projection was a standard \$1.50 to \$7 savings for every dollar spent by DoD for restructuring cost. The contractor’s initial projection was \$10 savings on each dollar spent. The current estimate pegs the savings at \$1.49 to every dollar spent.

The initial estimate was based upon reductions in overhead, material and manufacturing. Also, the company expected an increase in foreign sales would help produce a savings by achieving a more economical production quantity. Overall, an 11 to 16 percent reduction in follow-on contract price was expected.<sup>72</sup> In the end, the consolidation of FMC and Harsco-BMY only achieved 15 percent savings of their two year early projection. This consolidated company became known as United Defense Limited Partnership (UDLP). UDLP restructure included the combining and moving of production lines to York, Pennsylvania. This assisted in eliminating excess capacity and staffing.<sup>73</sup> Not all parties involved in this consolidation and generation of UDLP agree on the source of the savings. Tank Automotive Command (TACOM), a major subordinate command of U.S. Army Material Command (AMC), who purchased track vehicles from UDLP, believed that the cost reduction were due to restructuring and downsizing and savings would have occurred without restructuring. UDLP stated it came from the restructuring. The GAO analysis showed the savings tied to inflation rates and number of vehicles purchased.<sup>74</sup> The bottomline is that a cost savings was achieved; however, it was not near the original projection and slightly under the DoD stated goals on return.

According to BAH, mergers after September 30, 1996, had to show a \$2 savings for every up front reimbursement cost dollar in order to receive funding for plant rationalization. Congress did this by passing regulations which they thought would stop layoffs.<sup>75</sup>

Companies, despite overcapacity and its inefficiencies, are disincentivized to rationalize. This claim is based upon the need to show a 2 to 1 ratio of cost savings to cost reimbursement. Additionally, companies still facilitate based upon initial program plans vice a more realistic plan based on budget.<sup>76</sup>

The Booz-Allen, Hamilton report identified an approach for contractors to achieve improvement in their asset base. The approach suggests: define core/non-core capabilities and assets; develop a minimum realistic floor ("Base"); establish direct/indirect spending targets, considering the base, which supports future-year financial aspects; sizing a footprint for the base; and determining the rationalized organizational structure to support the base.<sup>77</sup> Contractors must make a commitment and execute this or a similar approach to achieve serious efficiencies.

In addition, while industry has tried to reduce cost through restructuring, the government has aggressively pursued acquisition reform initiatives. These have included the elimination of some military requirements and standards, use of Integrated Product Teams (IPTs) with industry and government members in making program and business decisions, and adopting commercial practices.<sup>78</sup>

Even though the discussion to this problem has been centered on contractor restructuring, associated cost savings, potential approach for contractors to follow, and identification of some government changes and involvement, there is an area that needs to be reemphasized. "For various reasons, defense manufacturers have not given emphasis to converting their products or capabilities to commercial ones."<sup>79</sup> If contractors were successful, this could reduce the overhead cost, sharing of the cost burden between military and commercial programs, and potentially increase the manufacturing quantity to a more economical production quantity.

### **MANUFACTURING TECHNOLOGY PROGRAM**

The Manufacturing Technology (MANTECH) program is the primary Department of Defense (DoD) and Army program looking for manufacturing technology development. Its funding is allocated in the budget on a yearly, varying basis.<sup>80</sup> The program is intended to develop new and improved manufacturing processes thus making the production of systems more affordable. The program explored those areas that industry would not pursue normally. The major areas of concentration were: Processing and Fabrication dealing with developing affordable processes by improving production floor and facility processes; and Advanced Manufacturing Enterprises which deals with accelerated implementation of practice, design, and information systems supporting a system.<sup>81</sup>

It is the MANTECH program expectation to fund initial demonstration, then that technology will be provided to industry for application in producing weapon systems. The government subsequently expects a reduction in future procurements and total life cycle cost for those programs the technology is used on.<sup>82</sup>

The Manufacturing Technology Advisory Group (MTAG) was established in 1968. It was designed to reduce duplication of effort, get joint participation in broad application projects, and promote dissemination of the MANTECH project results.<sup>83</sup> In February 1975, the Secretary of Defense placed more emphasis on the program by directing the Services to support it. April 1975, the Deputy Secretary of Defense directed the Services to set up centralized program management with staff to promote program objectives with authority. In addition, the Services were to identify new MANTECH efforts, looking for high ROI (return on investment) and plan to fund demonstrations.

On October 31, 1977, a new directive, DoD 5000.34, Defense Production Management, for product management identified the importance of MANTECH and the need to overcome identified deficiencies in weapon system proposals. Also, it identified the need to initiate

MANTECH projects for producibility.<sup>84</sup> In the 1979, Comptroller General's Report stated that the MANTECH Program did not promote the use of the project results in defense production. If the results (i.e., projects demonstrated) were not used then the program did not meet its objectives.<sup>85</sup> The 1979 data on the MANTECH Program showed that a larger percentage of funded projects were not implemented or showed no savings. Implementation rates/actual benefits to the services ranged from approximately 18 percent (Navy), 31 percent (Army) to 77 percent (Air Force).<sup>86</sup> In a review by the Comptroller General, the Army projects were geared toward mobilization requirements and not current production requirements. The Army is changing this along with getting better at tracking the projects. The Air Force made attempts to get contractor buy-in to implement projects from top level management and funded projects requiring significant contractor capital investment.<sup>87</sup>

The results of the Army's MANTECH Program showed that 80 percent of the projects were technically successful; however, only 48 percent were implemented or planned for defense production. The return on investment was 94 cents for every dollar spent; however, no consideration or value was given to improved maintainability or readiness. The Air Force results showed that the projects took 3 years to complete. They had 75 projects and had implemented 29 projects at a cost of \$33 million dollars with eight contractors. The return on investment was \$534 million dollars on defense related programs and \$399 million dollars on commercial programs.<sup>88</sup> While the MANTECH Program is a viable program, shortcomings were identified. Even though the program was designed to reduce acquisition cost and improve manufacturing producibility, problems included a lack of consistent ranking of projects for funding/effort, data not available nor projects tracked, and finally, no accountability of funding. The problems have been continuously worked.<sup>89</sup> Another problem that became evident was the amount of time, from project approval to completion, often years. During this period of time, the defense production requirements can and do change, making it hard to integrate into current DoD production needs.<sup>90</sup>

The 58 completed projects not used, ten were not used due to changes in production requirements, nine not technically successful, nine not economically feasible, and four required additional work. Three additional reasons projects not used included: contractor unwillingness to adapt the change; the need for a tooling or engineering change to implement; or a better, competing technology was found.<sup>91</sup> This program's results highlight some of the common problems that exist in all programs (e.g., change in requirements, better technology found, and contractor unwillingness).

The DoD position that Manufacturing Technology developed through the MANTECH program must be used by more than a single program otherwise the supported program needs to pay the cost, not the MANTECH Program. The MANTECH Program reduces potential duplication of effort and expenses and can be used to solve industry wide problems not just a single problem.<sup>92</sup> In order to improve this potentially excellent program, DoD must devise a procedure to ensure MANTECH results are used in defense system production and track and document project implementation and benefits.<sup>93</sup>

For future implementation, DoD needs to get upfront agreements that include selecting projects: with the highest probability of use, need and commitment; projects still needed by the identified program; that make technology available to the industrial base; and that establish a way to identify, measure and report benefits. Finally, projects must be reevaluated at completion to ensure the need was met.<sup>94</sup>

DoD needs to encourage greater use of MANTECH Projects. This requires program managers and other appropriate parties to be aware of anticipated benefits, before receiving funds of proposed projects, securing a willingness to use the technology; then survey contractors after project completion to see if implementation actually occurred.<sup>95</sup> Another recommendation is to establish a definite funding stream for this program. It has been proposed that this be done at the 1 percent level of the Army budget.<sup>96</sup>

In conclusion, MANTECH needs to get early agreement from all parties (i.e., program managers, contractor, MANTECH Program Office) to implement MANTECH project results on the production floor if technically successful and economically feasible. Also, successful MANTECH projects must be tracked to ensure they and other innovative techniques are used.<sup>97</sup>

Another test program identified in the 1984 Comptroller General's Report was the Industrial Modernization Incentive Program (IMIP). It was a top down factory analysis. It was to develop and track modernization projects (indirect and direct operation) in order to develop a strategic cost reduction and productivity improvement plan for the production facility.<sup>98</sup> However, this program was determined to be a cost driver by DoD and cancelled in May 1994.<sup>99</sup>

## **MANUFACTURING TECHNOLOGY: WHY, WHAT, WHO, WHERE, WHEN**

The primary purpose of manufacturing technologies is to increase productivity and product quality with fewer assets and at a lower cost. A better quality product can mean higher yield thus the need for additional shifts are reduced including the maintenance. The secondary affect of all this is a potential surge capability (working multiple shifts).<sup>100</sup> Flying in the face of this industry initiative is DoD's need to keep older systems operational by maintaining

production lines for old but still operational equipment and systems. This conflicts with contractors who are trying to upgrade systems to be competitive. In order to meet this problem, Army Depots have been called upon to take over some of the production requirement; however, they cannot do it all. Another alternative has been to maintain inactive or mothball facilities. This is an costly alternative in maintenance and meeting new tolerances required on products.<sup>101</sup>

As the manufacturing technologies rapidly change, one must remember to continually upgrade the manufacturing process.<sup>102</sup> Failure to adopt advanced manufacturing technologies and/or processes could compromise one's ability to survive.

Advance manufacturing technologies are essential for military products because they determine what systems, end items, and components can be produced at what cost, quality level and how fast.<sup>103</sup> Continuous investment in advanced manufacturing technologies is a defining characteristic of a manufacturing company on the leading edge. The initial investment is high; however, the total cost (development, acquisition, operational support, disposal) can be lower enabling the contractor to be more competitive.<sup>104</sup>

Increasingly complex weapon systems have promoted industrial specialization thus raising the likelihood that one's inability to accelerate production of a single component will prevent surge and mobilization production of an entire system.<sup>105</sup> Further, the reduction in the number of defense contractors and subcontractors threatened the loss of complete industries such as those manufacturing some machine tools, computer components, and bearings.<sup>106</sup>

Revolutionary advanced manufacturing tools are being introduced and developed at an increasingly rapid pace including modeling, and computer-integrated manufacturing. These are accompanied by changes in personnel practices.<sup>107</sup> New manufacturing technologies include: flexible manufacturing systems allowing contractors to produce multiple products on the same line; Just in Time (JIT) production to take out all non-value items like inventory, space, transportation and excess handling; In Process Quality using methods like Statistical Process control and getting away from inspection and embracing samples, metrics, and data; Concurrent Engineering to do things at the same time, performing tradeoff analysis and getting things done quicker; and Manufacturing Resource Planning (MPR II) a system supporting operations planning and execution by determining capacity requirements, inventory, bill of materials, and scheduling.<sup>108</sup>

Computer Integrated Manufacturing (CIM) links design, marketing, manufacturing, and business functions, in a manufacturing company, allowing access to all activities and information from the product concept to field support via a computer.<sup>109</sup> This enables all

members of the organization to participate, be knowledgeable, and execute the intended program.

Advanced manufacturing technologies have initiated many challenges. Defense contractors might be asked to be cost effective and make capital investment beyond peacetime military needs, simultaneously;<sup>110</sup> production bottlenecks have changed in type and nature; and manufacturing globalization brings forth new vulnerabilities and threatens the technological superiority of the U.S.<sup>111</sup>

The biggest problem with improving the DoD level of manufacturing technology is the DoD Acquisition System. The use of single-year contracts, awarding on lowest bid, and not total life cycle cost is detrimental. Industry also states the reduction of cost sharing on new development programs and use of fixed price development contracts will hamper their ability to improve manufacturing technology.<sup>112</sup>

### **CAN DOD ACHIEVE SAVINGS?**

DoD felt that by consolidations, mergers, and acquisitions its industries would be competitive. These have helped; however, a reduction of overcapacity is needed now to reduce the excess overhead cost. DoD rightfully views the reduction of underutilized excess capacity as a cost savings.<sup>113</sup>

The mergers and acquisitions produce cost savings, especially administrative; however, they are short term. Excess production and product design capabilities must be addressed.<sup>114</sup> Additionally, company reorganizations, teaming and joint ventures may not produce savings unless excess production is eliminated. Also, one must look at increasing sales (i.e., foreign military sales) as a way to use the excess capacity and spreading out the overhead cost.<sup>115</sup>

Government contractors must restructure so that an affordable and realistic defense can be achieved. In order to accomplish this, the government must chose a path and pay to reduce the excess capacity taking in the associated communities and future military plan.<sup>116</sup>

In 1996, the Senate discussed and voted on the payment of restructuring cost from acquisitions and mergers. This was in response to the payment of those costs starting in 1993 which has envisioned to lower overhead cost and reduce overcapacity during a period when defense procurement declined by 60 percent (1986-1996). It originally envisioned a stop to the spiral of the defense industry.<sup>117</sup> The consolidated cost payments in 1993 were a major change in policy. Previously drawdowns in the 1970s (Vietnam Drawdown) and production base climbs in the 1980s (military buildup years) did not receive a consideration.<sup>118</sup>

So the Department of Defense spent \$300 million dollars generating a savings of \$450 million dollars (1.5 to 1 ratio). However, most of the savings were negotiated cost dealings with

personnel (i.e., early retirement, severance pay, medical/dental and life insurance).<sup>119</sup> In addition, GAO analysis found less than 15 percent of the proposed savings actually materialized.<sup>120</sup> With this information, the Senate voted to do away with restructuring cost and established additional regulatory guidance and so the overcapacity continues to exist.

## **RATIONALIZATION ALTERNATIVES, MODERNIZATION AND DISCUSSION**

In reviewing the contractors industrial base and capabilities, it became obvious that prevalent facility overcapacity, and limited incentives for contractors to reduce these do not exist.

In addition, the modernization of these facilities is needed from a more efficient and effective operating environment. Initiatives, alternatives, and execution of those are needed to drive down the current overhead cost that continue to decrease DoD program budgets.

Manufacturing technology advances continue and have changed production, and reduced its bottlenecks. Flexible automation and modeling are but two examples of technology and techniques that are used to enhance our industrial preparedness. However, no national or overall effort has been made to capitalize and identify on other opportunities.<sup>121</sup>

Why have companies not taken this on? One of the biggest hurdles is the uncertainties of the DoD volume requirements. The requirements have a tendency to move on a year to year basis, discouraging contractors from making those capital investments. Contractors investment can only be justified if there is a large volume production run associated with the item,<sup>122</sup> something the government, as a customer, does not do well.

In addition, DoD will negotiate lower price contracts to reflect the cost savings each year of this yearly production/acquisition cycle. Thus, the contractor has less incentive to invest in manufacturing equipment that does not meet the unrealistic payback period of one year.<sup>123</sup>

Even though the Army Material Command (AMC) has been identified as needing to expand initiatives aimed at getting the contractors to upgrade their technology and their competitiveness,<sup>124</sup> this needs to be a DoD wide initiative. Since a majority of the programs are multi-service in nature. The technology and process modernization will assist all, thus the government needs to provide the funding from a consolidated fund unless the benefit derived will only be Service specific. As stated previously, maybe one percent of the budget should be set aside to fund manufacturing technology improvements with a portion of the captured cost savings being returned to the program coffers for future technology improvements.

In addition to modernizing the facilities, steps must be taken to reduce overcapacity and where it is safe and prudent to do so. If this is not done, we will have increasing the overhead costs, and a reduction in the Services buying power.

There are multiple alternatives that can be accomplished.

First alternative is status quo. DoD does nothing to assist or incentivize contractors. If this alternative is taken, history has shown a potential need of doubling our budget while receiving 65 percent less product or service over the next twenty years.

Second, while the DoD MANTECH program supports implementation of critical manufacturing process to improve affordability, there is Title III of the Defense Production Act that provides financial incentives to domestic contractors for the establishment, modernization or expansion of their production capacity and capability.<sup>125</sup> Title III could be the vehicle to expand, modernize or establish our domestic production capacity and capabilities while insuring essential resources and technologies are available. The program accelerates items from research and development to production phase plus inserting new technology into the system. However, Title III is only available if no or insufficient capability exist.<sup>126</sup> As written, it does not allow for use in reducing inefficiency and overcapacity of existing contractor facilities. It should be amended.

Title III incentives includes purchase/lease of equipment, loans/loan guarantee, purchase orders/commitments and substitutions. The typical incentives are loans or loan guarantee.<sup>127</sup> This means the contractor must come up with the funding and the government could change its position next year when the budget comes out.

The third alternative deals with a proposed DoD policy allowing contractors to retain a percentage of their internal restructuring savings, through an adjustment to profits for a period of years.<sup>128</sup> This might provide contractors a serious incentive. This could be a short run measure by which DoD would improve the sharing of cost savings with that contractor for downsizing. It does not mean that financial assets would be portionally reduced to tangible assets nor does this guarantee excess capacity will go away in the defense sector.<sup>129</sup> It does mean that the government or DoD would probably need to find financing alternatives to assist industry in rationalizing itself.<sup>130</sup> This alternative is similar to the Industrial Modernization Incentive Program (IMIP) discussed earlier, program aimed at improving the manufacturing equipment and processes of specific contractor plants. The goal is to lower unit cost and improve the industrial base with the development cost and cost savings to be shared by the government and contractor. It was anticipated that DoD industrial preparedness funds, contractor investment, and weapon systems contracts would pay for the development, analysis, and implementation.

The payback period was expected to be 3 to 6 years with a Return of Investment (ROI) between 4 to 1 and 10 to 1.<sup>131</sup> This alternative has identified a previous program that might provide a basis; however, industry must rationalize to reduce cost. DoD would share in these savings with industry (could use the value engineering model to determine savings distribution). Also, DoD would need to revise profit guidelines to reduce award for fixed assets and add incentives to reward contractors for cost efficiencies.<sup>132</sup>

A final alternative would be to develop incentive strategies that promote innovation and cost reduction.<sup>133</sup> A portion of this approach would include providing direct incentives to the contractors for any investments. Also, DoD and Army needs to streamline and shorten the acquisition process allowing for changes to be quickly implemented.<sup>134</sup>

Another potential incentive to reduce excess capacity over a certain time period, would be to tie it to the payment of interest by the government. This offer would be extended to only those contractors who have overcapacity or were less efficient.<sup>135</sup> This alternative would enable the government and DoD to review any and all potential initiatives to see what is actionable. It provides flexibility; however, it lacks a consolidated structure which is a shortcoming.

DoD has invested in companies to secure capability and capacity, simplifying specifications to reduce production cost or go commercial, increase requirements to obtain an economical quantity, or compensate for pricing misjudgments.<sup>136</sup> However, this says nothing about getting the contractor to rationalize infrastructure or modernize the facilities.

## **TRENDS AND CONCLUSION**

Today, industry continues to struggle with excess capacity, modernization of the facilities, funding constraints, and government business practices.

Contractors have a difficult time effectively managing their assets when their customer (the government) changes the funding profile annually. This continues to make the contractor execute sub-optimal decisions. Some times DoD has procured less than planned quantities at higher than per unit costs. This compounds the problem further.<sup>137</sup>

Contractors have started to embrace advance manufacturing technology by producing high quality, lower-life cycle cost products, and establishing an ability to change between products; however, there is a way to go here.

The government has made changes in its acquisition process by simplifying or eliminating military specifications and standards, increasing flexibility and interchangeability of commercial and military lines, use of total life cycle cost in determining best value, and use of multi-year procurements to a limited degree.<sup>138</sup>

In addition, there has been a push make industrial preparedness a part of the acquisition process. It should start with design and continue throughout critical item and major system life cycles, be a factor in source selection, become a contract requirement, and insure surge/mobilization planning be a criteria for contract award.<sup>139</sup>

Even after all that has been done, the defense industry must continue to push toward common commercial and defense industry and technologies, thereby getting rid of barriers especially cost-base production contracts.<sup>140</sup>

Industry must continue to expand its market share internationally, however, there they face export control limitations. Industry is trying to build partnerships with European industries; however, the European's face the same challenges of overcapacity and underutilization. Defense industry must seek ways to enter into the commercial markets.<sup>141</sup>

In conclusion, DoD, with congressional support, needs to develop and implement a clear policy on consolidation including a sensible reduction of excess capacity. Alternative three, discussed previously, should be implemented. A cost sharing arrangement to incentivize the contractor to reduce overcapacity and modernize their facilities is required. The "seed" money to assist the contractor could come from industrial preparedness funds earmarked as such. However, one should expect a reasonable rate of return on investment, say up to 6 years. The actual captured savings should be made available for other similar projects through a centralized fund specifically for the initiative to reduce overcapacity and modernized facilities. These savings should not be taken as decrements to a program especially before materialization as Congress and DoD have a tendency to do today. Additionally, enforceable contract language needs to be incorporated in the execution of this alternative that would forbid the billing of overcapacity to the overhead or specific contracts after an implementation period associated with modernization efforts. This alternative could envision the need for multi-year funding and program authority for this project, and programs at the contractor's facility. Which some believe could assist in reducing product cost by establishing the government's commitment to the project and program.

In closing, a quote: "United States pays too much for its weapons because it builds them inefficiently in too many underutilized facilities. These excess facilities are sustained because we lack a clearly identified enemy. It is jobs rather than fear, the desire for pork rather than a security panic that drives weapons acquisition."<sup>142</sup>

WORD COUNT = 7,617

## ENDNOTES

<sup>1</sup> John R. Harbison et al., "U.S. Defense Industry Under Siege—An Agenda for Change," Viewpoint (Unnamed: Booz-Allen and Hamilton, Inc., 2000), 10.

<sup>2</sup> *Ibid.*, 10.

<sup>3</sup> Defense Science Board Task Force, "Preserving a Healthy and Competitive U.S. Defense Industry to Ensure Our Future National Security," Final briefing slides, November 2000, 19.

<sup>4</sup> *Ibid.*, 13.

<sup>5</sup> Department of Defense, Annual Industrial Capabilities Report to Congress, (Washington, D.C.: Department of Defense, January 2001), 15.

<sup>6</sup> *Ibid.*, 65.

<sup>7</sup> Defense Science Board Task Force, 12.

<sup>8</sup> *Ibid.*, 6.

<sup>9</sup> *Ibid.*, 7.

<sup>10</sup> National Research Council, Industrial Preparedness: National Resource and Deterrent to War, (Washington, D.C.: National Academy Press, 1990), 46.

<sup>11</sup> *Ibid.*, 6.

<sup>12</sup> Defense Science Board Task Force, 44.

<sup>13</sup> *Ibid.*, 13.

<sup>14</sup> John Deutch, "Consolidation of U.S. Defense Industrial Base," Acquisition Review Quarterly, (Fall 2001), 143.

<sup>15</sup> Defense Science Board Task Force, 23.

<sup>16</sup> Charles W. Cruik et al., Logistic Management Institute, Improving DOD Relations With Industry, (Bethesda: Logistics Management Institute, October 1987), 2-2/3.

<sup>17</sup> *Ibid.*, 2-1.

<sup>18</sup> Deutch, 138.

<sup>19</sup> *Ibid.*, 139.

<sup>20</sup> *Ibid.*, 139.

<sup>21</sup> Ibid., 138.

<sup>22</sup> Ibid., 142.

<sup>23</sup> General Accounting Office, Acquisition Reform: Defense Management Report, Saving Initiatives (Washington, D.C.: U.S. General Accounting Office, January 1997), 14.

<sup>24</sup> Deutch, 141.

<sup>25</sup> Defense Science Board Task Force, 22.

<sup>26</sup> General Accounting Office, Defense Industry: Trends in DoD Spending, Industrial Productivity, and Competition, (Washington, D.C.: U.S. General Accounting Office, January 1997), 4.

<sup>27</sup> Ibid., 5.

<sup>28</sup> Cruik, 2-7.

<sup>29</sup> General Accounting Office, Overhead Cost: Defense Industry Initiatives to Control Overhead Rates, (Washington, D.C.: U.S. General Accounting Office, May 1995), 1.

<sup>30</sup> Ibid., 1.

<sup>31</sup> Ibid., 3.

<sup>32</sup> Ibid., 8.

<sup>33</sup> Harbison, 19.

<sup>34</sup> Defense Industry, 4.

<sup>35</sup> Harvey M. Sapolsky, "Buying Weapons Without an Enemy," Breakthrough (Spring 2001) (Carlisle Barracks: U.S. Army War College, Academic Year 2002), 363.

<sup>36</sup> General Accounting Office, Defense Industry Consolidation: Competitive Effects of Mergers and Acquisitions, (Washington, D.C.: U.S. General Accounting Office, March 4, 1998), 1.

<sup>37</sup> Captain Bob Magee, "Global Changes in the Defense Industrial Base: Challenges and Opportunities," Briefing slides, (Washington, D.C.: Office of the Deputy Undersecretary of Defense (Industrial Policy), January 28, 2002), 6.

<sup>38</sup> Defense Industry Consolidation, 2.

<sup>39</sup> Magee, 7.

<sup>40</sup> Defense Industry Consolidation, 7.

<sup>41</sup> Defense Industry, 23.

<sup>42</sup> Annual Industrial Capabilities Report, 2.

<sup>43</sup> Defense Industry, 21.

<sup>44</sup> Annual Industrial Capabilities Report, 3.

<sup>45</sup> Ibid., 6.

<sup>46</sup> Magee, 19.

<sup>47</sup> Sapolsky, 359.

<sup>48</sup> Annual Industrial Capabilities Report, 16.

<sup>49</sup> Ibid., 6.

<sup>50</sup> Ibid., 6.

<sup>51</sup> Magee, 20-21.

<sup>52</sup> Annual Industrial Capabilities Report, 11.

<sup>53</sup> Ibid., 15.

<sup>54</sup> Ibid., 14.

<sup>55</sup> Defense Contract Management Command Industrial Analysis Support Office, Report to U.S. Army's Aviation Missile Command (AMCOM): Rotary-Wing Industrial Capability Assessment, (Philadelphia: Defense Contract Management Command Industrial Analysis Support Office, August 20, 1999), 1.

<sup>56</sup> Ibid., iii.

<sup>57</sup> Ibid., 3.

<sup>58</sup> Ibid., 6.

<sup>59</sup> Ibid., 10.

<sup>60</sup> Ibid., 9.

<sup>61</sup> Ibid., 12.

<sup>62</sup> Industrial Analysis Support Office, "U.S. Rotary-Wing Aircraft Prime Contractor Facilities," Briefing slides, (Philadelphia: Industrial Analysis Support Office, Draft), Table A/B.

<sup>63</sup> Report to U.S. Army's Aviation Missile Command (AMCOM), 15.

<sup>64</sup> Sapolsky, 362.

<sup>65</sup> Harbison, 2.

<sup>66</sup> Ibid., 15.

<sup>67</sup> Ibid., 14.

<sup>68</sup> Defense Industry, 25.

<sup>69</sup> General Accounting Office, Defense Restructuring Cost: Projected and Actual Savings From Martin-Marietta Acquisition of GE Aerospace (Washington, D.C.: U.S. General Accounting Office, September 1996), 4-5.

<sup>70</sup> Ibid., 6.

<sup>71</sup> Ibid., 2.

<sup>72</sup> General Accounting Office, Defense Contractor Restructuring: First Application of Cost and Cost Savings Regulation (Washington, D.C.: U.S. General Accounting Office, April 1996), 4.

<sup>73</sup> Ibid., 2.

<sup>74</sup> Ibid., 5.

<sup>75</sup> Harbison, 10-11.

<sup>76</sup> Ibid., 24.

<sup>77</sup> Ibid., 19.

<sup>78</sup> Defense Industry, 2.

<sup>79</sup> Ibid., 24.

<sup>80</sup> National Research Council, 58.

<sup>81</sup> Annual Industrial Capabilities Report, 76.

<sup>82</sup> Comptroller General of the United States, Manufacturing Technology – A Cost Reduction Tool at the Department of Defense That Needs Sharpening, (Washington, D.C.: U.S. General Accounting Office, September 11, 1979), 2.

<sup>83</sup> Ibid., 2.

<sup>84</sup> Ibid., 2.

<sup>85</sup> Ibid., 14.

<sup>86</sup> Ibid., 9.

<sup>87</sup> Comptroller General of the United States, DoD Manufacturing Technology Program – Management Is Improving But Benefits Hard to Measure, (Washington, D.C.: U.S. General Accounting Office, November 30, 1984), 20.

<sup>88</sup> Ibid., 8.

<sup>89</sup> Manufacturing Technology, 6.

<sup>90</sup> DoD Manufacturing Technology, iii.

<sup>91</sup> Ibid., 12.

<sup>92</sup> Ibid., 34.

<sup>93</sup> Manufacturing Technology, 17.

<sup>94</sup> DoD Manufacturing Technology, 36.

<sup>95</sup> Ibid., v.

<sup>96</sup> National Research Council, 58.

<sup>97</sup> DoD Manufacturing Technology, 21.

<sup>98</sup> Ibid., 16.

<sup>99</sup> Department of Defense, Updated Compendium of the Office of Primary Responsibility (OPR) Reports, June 1996; available from <http://www.acq.osd.mil/ar/opr96mn.htm>; Internet: Accessed 28 March 2002, 10.

<sup>100</sup> National Research Council, 26.

<sup>101</sup> Ibid., 36.

<sup>102</sup> Ibid., 6.

<sup>103</sup> Ibid., 8.

<sup>104</sup> Ibid., 8.

<sup>105</sup> Ibid., 2.

<sup>106</sup> Ibid., 2.

<sup>107</sup> Ibid., 8.

<sup>108</sup> Ibid., 15-17.

<sup>109</sup> Ibid., 15.

<sup>110</sup> Ibid., 9.

<sup>111</sup> Ibid., 6.

<sup>112</sup> Ibid., 19

<sup>113</sup> Defense Industry, 24.

<sup>114</sup> Ibid., 24.

<sup>115</sup> Ibid., 25.

<sup>116</sup> Sapolsky, 363.

<sup>117</sup> U.S. Congress Senate, Senate Record Vote Analysis Defense Appropriations/Contractor Consolidation Costs, 104<sup>th</sup> Congress, 2d session, 18 July 1996; available from <http://www.senate.gov/~rpc/rva/1042/1042198.html>; Internet; Accessed 20 December 2001, 1.

<sup>118</sup> Ibid., 2.

<sup>119</sup> Ibid., 1.

<sup>120</sup> Ibid., 2.

<sup>121</sup> National Research Council, 2.

<sup>122</sup> Ibid., 21.

<sup>123</sup> Ibid., 21.

<sup>124</sup> Ibid., 2.

<sup>125</sup> Annual Industrial Capabilities Report, 48.

<sup>126</sup> Ibid., 97.

<sup>127</sup> Ibid., 97.

<sup>128</sup> Ibid., 37.

<sup>129</sup> Deutch, 145-146.

<sup>130</sup> Defense Science Board Task Force, 34.

<sup>131</sup> National Research Council, 22.

<sup>132</sup> Defense Science Board Task Force, 33.

- <sup>133</sup> Ibid., 34.
- <sup>134</sup> National Research Council, 57.
- <sup>135</sup> Deutch, 146.
- <sup>136</sup> Annual Industrial Capabilities Report, 43.
- <sup>137</sup> Harbison, 12.
- <sup>138</sup> National Research Council, 28.
- <sup>139</sup> Ibid., 56.
- <sup>140</sup> Defense Science Board Task Force, 37.
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